LAKE STATES ASPEN REPORT NO. 7

MECHANICAL PROPERTIES OF ASPEN

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FOREWORD

During and since World War II, there has been increasing interest in aspen (*Populus tremuloides*) in the Lake States, its availability and supply, properties and uses, and management. Aspen is a tree of primary importance in 20 million acres or 40 percent of the total forest area of the three Lake States - Michigan, Minnesota, and Wisconsin.

At an informal meeting at Madison, Wisconsin, in January, 1947, forestry representatives of several federal, state, and industrial groups in the Lake States agreed that it would be desirable to bring up to date what is known on aspen and make it available to anyone interested. The job of preparing this information in the form of reports was assigned to each of the groups listed below. The reports will be duplicated as rapidly as completed, and the entire project should be finished by the end of 1947. Each report will concern one aspect of the subject. Copies will be available from the Lake States Forest Experiment Station or from each contributor.

Report Number	Subject
1	Aspen Properties and Uses
2	Aspen Availability and Supply
3	Logging Methods and Peeling of Aspen
4	Milling of Aspen into Lumber
5	Seasoning of Aspen
6	Aspen Lumber Grades and Characteristics
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9	Aspen Lumber for Building Purposes
10	Aspen for Containers
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12	Small Dimension and Other Industrial Uses of Aspen
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16	Aspen for Excelsior
17	Aspen Defiberization and Refining of Product
18	Chemical Utilization of Aspen
19	Preservative Treatment of Aspen
20	Marketing of Aspen
21	Possibilities of Managing Aspen

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MECHANICAL PROPERTIES OF ASPEN

By
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The clear wood of aspen has inherent properties of merit. Several of these properties are familiar to a large proportion of the general public, for some of the common types of matches are made of this wood. The requirements of wood for matches are exacting in that the wood must combine straightness of grain, ease of splitting, ease of working, and toughness. To meet such rigid requirements, a wood must be suitable for other uses as well. The fact that aspen is not used more widely for other purposes lies not in the wood itself but in other factors, such as cost, distribution of stand, and availability in desired sizes and grades. Cost, demand, and harvesting and marketing practices change as conditions change. The fact that in the past some of these factors have been adverse to the utilization of aspen stands does not mean that the wood cannot be used more widely now and in the future at a reasonable cost and without sacrifice of the quality of the product.

The utilization of the existing stands of aspen has been retarded in part because the lumber buying public is not generally familiar with the properties of the wood. There has been little incentive to inform consumers of the properties of a wood which was but little used. There has been a very general tendency to underrate all of the properties of aspen. Other species, such as cottonwood, Eastern hemlock, and sweetgum have passed through a similar stage. A comparison of the properties of aspen with those of other well-known woods will correct some of the existing erroneous ideas and should aid in better utilization of the species.

The other woods with which aspen is compared are those that are used for many of the same purposes. In addition, comparison is made with a few of the best-known species of the Lake States. The comparisons are made in table 1 by using aspen as 100 points. The other woods are shown as so many points above or below aspen.

Weight per Cubic Foot (Green and Air-dry)

Aspen is one of the hardwoods of light weight. In a thoroughly air-dry condition (12 percent moisture content in the Lake States), aspen weighs, on the average, 27 pounds per cubic foot. One thousand board

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1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Wisconsin, Madison, Wisconsin.

feet of nominal 1-inch dry aspen lumber surfaced to a thickness of 25/32 inch would weigh about 1,760 pounds. Similar amounts of other woods would weigh: basswood about 1,690 pounds, eastern cottonwood 1,830 pounds, sugar (hard) maple, about 2,870 pounds. A comparison of the weight of air-dry aspen with other species, all valued for their lightness, is shown in figure 1.

Generally the lighter the weight of the dry wood the weaker and softer it is. Like all general rules, this one has some exceptions. Thus, although yellow-poplar is heavier and harder than aspen, aspen is higher in shock resistance. Big tooth aspen and aspen weigh the same, but big tooth aspen is harder and tests higher in all strength properties except shock resistance or toughness (table 1). Such exceptions usually occur where differences in weight are small. Where differences in weight are large, as between maple and aspen, the general rule holds true.

The light weight of aspen is obviously an asset or a liability, depending upon the use to which the wood is put. Lightness is an asset in boxes, pails, and other containers because it reduces the cost of transportation. Likewise, wood of light weight is preferred for spools and for excelsior. Ladders made of lightweight wood are easier to handle than those made of heavy woods. Woods of light weight are also preferred for toys for small children. The tare or dead weight of vehicle body parts may be lessened by the use of lightweight woods. For flooring, stringers, butcher blocks, and similar uses, woods that are heavier and harder than aspen are preferred. Aspen is best adapted to uses where lightness is more important than strength and where a combination of strength and lightness is desired.

Shrinking and Swelling

Small shrinkage is one of the favorable properties of aspen. Changes of dimension with changes in atmospheric conditions are the source of many troubles encountered in the use of wood. The objections to changes in size of interior trim, doors, windows, staves, and ready-cut stock are well known.

The shrinkage and swelling of aspen with moisture changes is less than that of basswood, eastern cottonwood, or yellow-poplar, woods favored by manufacturers of articles with small shrinkage requirements. Eastern white pine and northern white cedar, woods widely known for their small amount of shrinkage, shrink less than aspen. The difference between these species and aspen, however, is less than the difference between aspen and basswood.

Comparisons of the shrinkage of aspen with that of several other species are shown in figure 2, which is based on the total shrinkage from a green to an over-dry condition. The relative change in dimension that may be expected with different species in service with any given change in atmospheric or moisture conditions may be observed in figure 2.

Trouble from changing dimension in service is more often caused by the use of green or insufficiently dried lumber than by the inherently high shrinkage of the species. Any advantage which aspen may have as a result of its low shrinkage may be more than lost by the use of wet lumber. The difference in the change in dimension in drying from 20 percent and 12 percent moisture content to 6 percent content is greater than the difference in the shrinkage of aspen and any of the species shown in figure 2. The use of aspen or any other species, therefore, will not insure small change in dimension unless the wood is dried to approximately the average moisture content it will have in use.

Bending Strength

The clear wood of aspen has the same bending strength as eastern white pine (fig. 3). Eastern white pine has been used for years in construction work where bending strength is important. The clear wood of eastern spruce and eastern hemlock, two species also used largely in construction, is slightly higher in bending strength than that of aspen. The bending strength of construction lumber is dependent more upon the defects present than upon the strength of the clear wood. This along with other factors means that aspen has better prospects for industrial and fabricated uses requiring small, clear pieces than for construction uses. Brush and broom handles, toys, matches, kitchen utensils, and washboards are examples of industrial uses requiring small, clear pieces. Although properties other than bending strength are usually of major importance in such uses, some bending strength is necessary for satisfactory service.

The use of aspen where bending strength is of first importance probably will always be limited. Aspen lumber is not generally available in the sizes and grades desired for construction work. Small amounts for construction are sometimes used locally, but the largest use of aspen timber for construction purposes is in round form for mine timbers. Even as mine timbers, the use of aspen is confined almost entirely to mines close to aspen stands. Where mine timbers must be shipped in, heavier, stronger, and more decay-resistant woods are preferred.

Compressive Strength (Endwise)

Aspen is used in only a few cases where high compressive strength (endwise) is desired. Compressive strength (endwise) is an important requirement of posts and short columns that are required to support heavy loads. Such structural members are usually 6x6 inches or larger in cross section. Very little material of this character can be produced from aspen because of the small size of the tree.

Occasionally pieces 2x2 inches or less in cross section and 20 inches or shorter in length are required to support a heavy load. Such posts, to have an equal load-carrying capacity, should be slightly larger than cottonwood or jack pine posts, but may be somewhat smaller than balsam poplar or eastern white pine (fig. 4). Mixed lots of posts, sold as "popple," "poplar," or "cottonwood," average higher in strength than

straight lots of aspen posts. This is because of the higher compressive strength (endwise) of cottonwood and big tooth aspen.

The compressive strength of aspen is comparatively low. However, it is generally sufficient for most of the uses into which the species goes, inasmuch as in these uses other properties are more important than compressive strength.

Shock-resisting ability

Aspen is relatively shock resistant for a lightweight wood. Basswood, yellow poplar, and eastern white pine, woods noted for their softness and light weight, are lower in shock-resisting ability than aspen (fig. 5).

Shock-resisting ability, or toughness, is dependent on the dry weight of a wood; therefore, the slightly heavier cottonwood and jack pine are somewhat more shock resistant than aspen. Very heavy hardwoods, such as ash and elm, are much higher in this property than aspen.

The shock resistance possessed by aspen increases its range of usefulness. It is an asset in crating, consequently much aspen is used for this purpose, particularly in the form of barky strips. Basket hoops, canoe frames, and ladders are examples of other uses employing lightweight softwoods, where shock resistance is also a desired property. Even for small articles, such as golf tees, matches, and parts of toys, shock resistance is an advantage. The well-known qualities of aspen excelsior are largely due to the toughness of the wood combined with other properties desired for this material. In general, while the shock-resisting ability and other properties of aspen are not sufficient to meet the requirements for such uses as ax handles, pitchfork handles, baseball bats, and hockey sticks, they are sufficient to meet the requirements for the uses to which lightweight softwoods are usually put.

Hardness (or Softness)

A number of woods such as aspen, eastern white pine, basswood, and yellow poplar are in demand largely because of their softness. Aspen, basswood, and balsam fir have about the same average softness. They are softer than eastern white pine and yellow poplar (fig. 6).

The greatest advantage of the softness of aspen is in the working of the wood. Wood for excelsior, matches, baskets, dowels, veneers, and spools must be easy to cut or shape. For some uses, such as drawing and drafting boards, softness is desired. Aspen is adapted to uses where softness is desired either in manufacture or in service.

Aspen is soft and uniform in texture, i.e., it does not have alternate bands of hard and soft wood. Such woods are easier to work than those with non-uniform texture. In this respect aspen is very similar to basswood and yellow poplar, which are preferred for a number of uses

because of their softness and uniform texture. Aspen can meet requirements for a combination of uniformity of texture and softness equally as well as either yellow poplar or basswood.

Stiffness

Aspen is not a stiff wood. It will bend more under a given load, other things being equal, than jack pine, basswood, or eastern white pine, but less than balsam poplar or northern white cedar. The stiffness of aspen is compared with that of a number of other species in figure 7. The comparisons are for clear wood but apply almost as well to wood containing knots or other defects, for defects have little if any influence on stiffness.

Stiffness is one of the important requirements of joists, studs, and other framing material. Aspen framing material would have to be somewhat larger in size than that of eastern spruce or eastern hemlock to have equal stiffness. Aspen is used for framing only in small quantities, as it is not available in as many sizes and grades as a number of the coniferous woods.

In most of the uses to which aspen is put, stiffness is not of importance. The stiffness of aspen is such that oversizes are not necessary to obtain sufficient stiffness for such uses as baskets, boxes, small handles, and beekeeper's supplies.

Nail-holding Power

The average holding power of a sevenpenny, cement-coated nail driven 1 1/4 inches into the side grain of dry aspen is 194 pounds2/ The same sized nail driven into green aspen would have about the same holding power when first driven. The holding power would, however, decrease rapidly as the wood dried. The holding power of the nails driven into green aspen is only about 20 pounds after the wood has thoroughly dried.

The nail-holding power of aspen is comparatively low, about the same as that of basswood and eastern cottonwood. Jack pine, eastern hemlock, and eastern white pine have a higher nail-holding power than aspen (fig. 8). More or larger nails must, therefore, be used with aspen to obtain a nail-holding power equal to that of the latter woods, provided they split no more than aspen in nailing. Fortunately the softness and uniform texture of aspen usually permit the use of a nail large enough to obtain the necessary nail-holding power without undue hazard from splitting. For uses, such as framing, where nail-holding power is desired to hold a covering, an increase in the size or number of nails is not generally

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2/"Nail-holding Power of Various Species of Wood," by L. J. Markwardt and J. M. Gahagan, Forest Products Laboratory, published in THE TIMBERMAN, August 1929, the SOUTHERN LUMBERMAN of July 15, 1929, contains detailed data on nail-holding power of 50 species including aspen.

necessary to obtain satisfactory nail-holding power. Even in standard food boxes where the nailed joints are usually the weakest parts, recent tests at the Forest Products Laboratory showed that it was not necessary to increase the size or number of nails in aspen boxes to obtain satisfactory resistance to rough handling.3/ The aspen boxes stood more rough handling than boxes of a number of species with higher nail-holding power. The smaller tendency of aspen to split at the nails was apparently sufficient to more than compensate for its lower nail-holding power.

Tests at the Forest Products Laboratory indicated that nails driven into green aspen lose a large proportion of their nail-holding power when the wood has thoroughly dried. Satisfactory service cannot be expected when nails are driven into green aspen and the wood allowed to dry out later in service. It is poor practice to nail any species while in a green condition, but it is especially so with aspen.

Splitting

Aspen is straight grained and consequently easy to split. In this respect it is about the same as eastern spruce. Eastern cottonwood and yellow poplar are much harder to split than aspen; balsam fir and eastern hemlock are somewhat easier (fig. 9).

Some uses requires a wood that is easy to split and others, a wood that is hard to split. Matches, toothpicks, and shoe pegs are uses that require easily split woods; uses such as vehicle body parts, where bolts are used for fastenings, require wood with high splitting resistance. Aspen is better suited to the first than to the second type of use.

Splitting in nailing is dependent more upon the softness and texture of wood than upon the splitting resistance. The softness and uniform texture of aspen are responsible for its splitting less in nailing than many harder woods with higher splitting resistance. Washboards, brooms, and boxes require woods with little tendency to split in nailing. Aspen is well adapted to such uses because its low splitting resistance is more than offset by its softness and texture, resulting in a low tendency to split in nailing. The tendency of small or thin parts, such as egg case tops, sides, or bottoms, to split in nailing can be materially reduced by the use of blunt-pointed nails, but at some sacrifice in holding power. Aspen veneer or thin shooks can often be successfully nailed with blunt-pointed nails when it is impractical to reduce splitting sufficiently by reducing the size of the nail.

3/ Results of these tests on boxes made of aspen and eight other woods are given in articles by T. A. Carlson, published in PACKAGES, 32, No. 3; 11, 14, 16, 22; March 1929; PACKING AND SHIPPING, 55, No. 12; 21-25, March 1929; and MISSISSIPPI VALLEY LUMBERMAN, 60, No. 11; 26-27, March 15, 1929.

Table 1 - Average mechanical and physical properties of clear wood of aspen compared with other species1/

Species	Weight per cubic foot: Green (1)	Weight per cubic foot: At 12 percent moisture content (2)	Shrinkage (3)	Bending strength (4)	Compressive strength (endwise) (5)	Stiffness (6)	Hardness (7)	Shock resistance (8)	Nail-holding power (9)	Splitting resistance (10)
	Pounds	Pounds	Points	Points	Points	Points	Points	Points	Points	Points
Aspen	43	27	100	100	100	100	100	100	100	100
Bigtooth aspen 2/	43	27	105	105	119	121	123	94	105	131
Basswood	41	26	142	97	107	118	100	81	101	118
Eastern cottonwood 2/	49	28	124	98	110	115	116	109	99	169
Balsam poplar 2/	40	23	94	76	83	89	81	64	...	96
Yellow poplar	38	28	107	113	117	126	129	87	112	171
Northern white cedar	28	22	62	79	90	73	97	70	80	93
Balsam fir	45	26	93	94	116	110	100	75	...	76
Eastern hemlock	50	28	88	114	136	113	165	100	117	88
Jack pine	50	30	92	102	126	104	155	116	129	127
Eastern white pine	36	25	75	100	116	111	113	82	114	98
Eastern spruce (commercial) 3/	34	28	113	111	129	121	126	101	113	100

1/ This table is for use in comparing the clear wood of aspen with that of other species, or for comparing aspen lumber with lumber of other species containing like defects.
2/ Sometimes sold mixed with aspen under the commerical name of popple.
3/ Average red and white spruce.

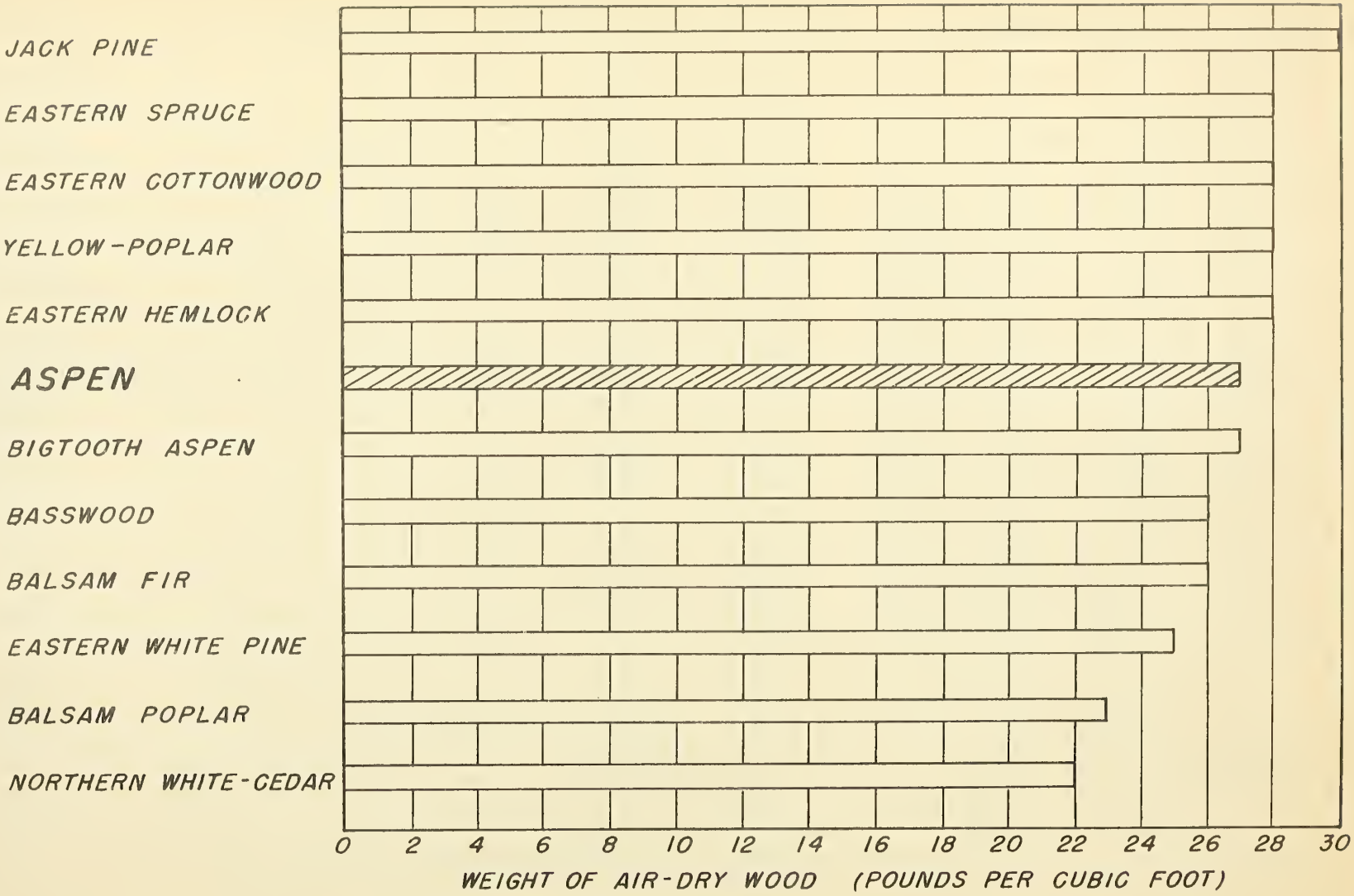

Figure 1.--Weight of air-dry aspen, 12 percent moisture content, compared with the weight of several other species.

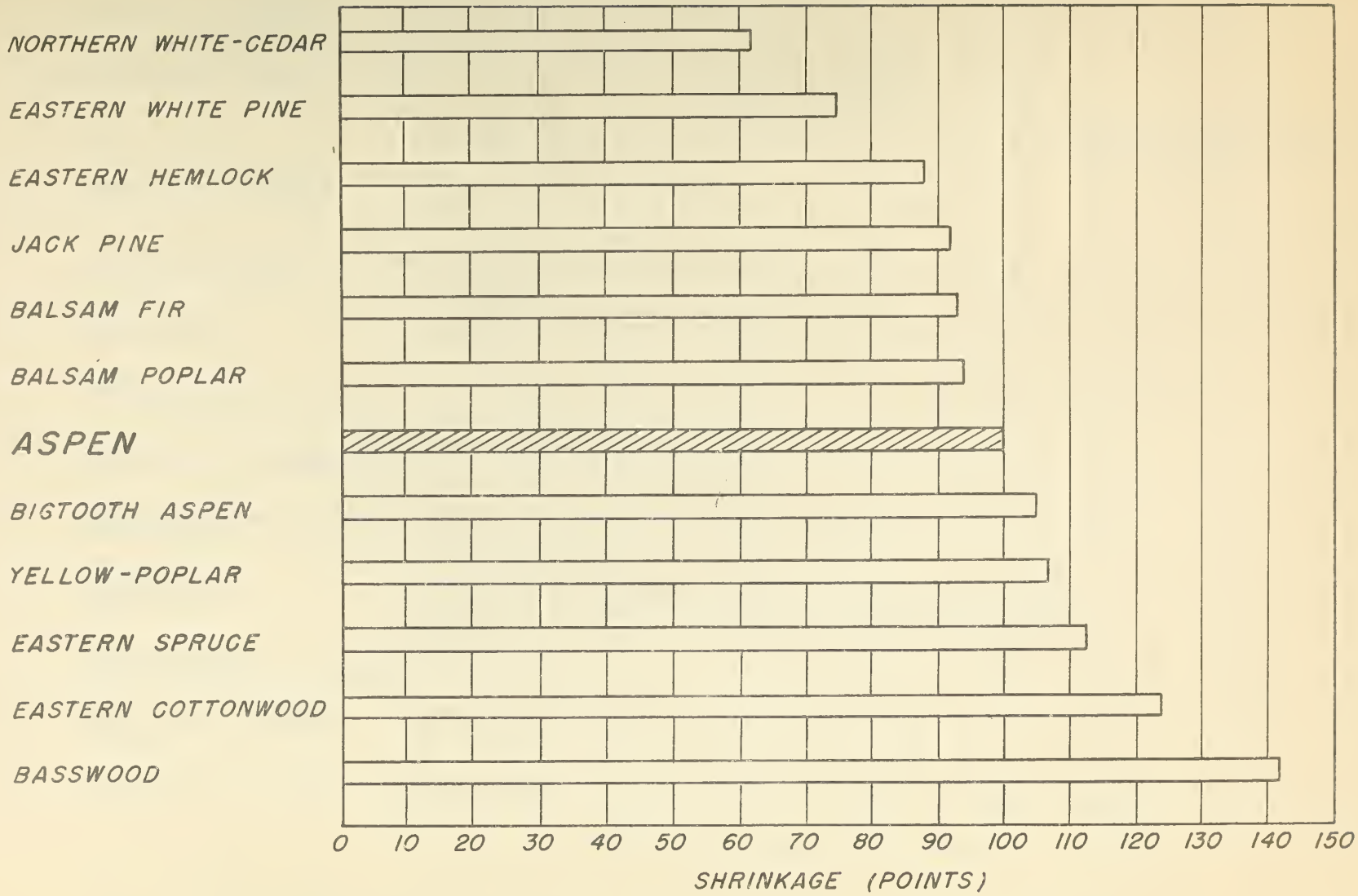

Figure 2.--Comparison of the average shrinkage of aspen with several other species. Aspen has a low shrinkage and consequently will not expand or contract much with slight changes in moisture content.

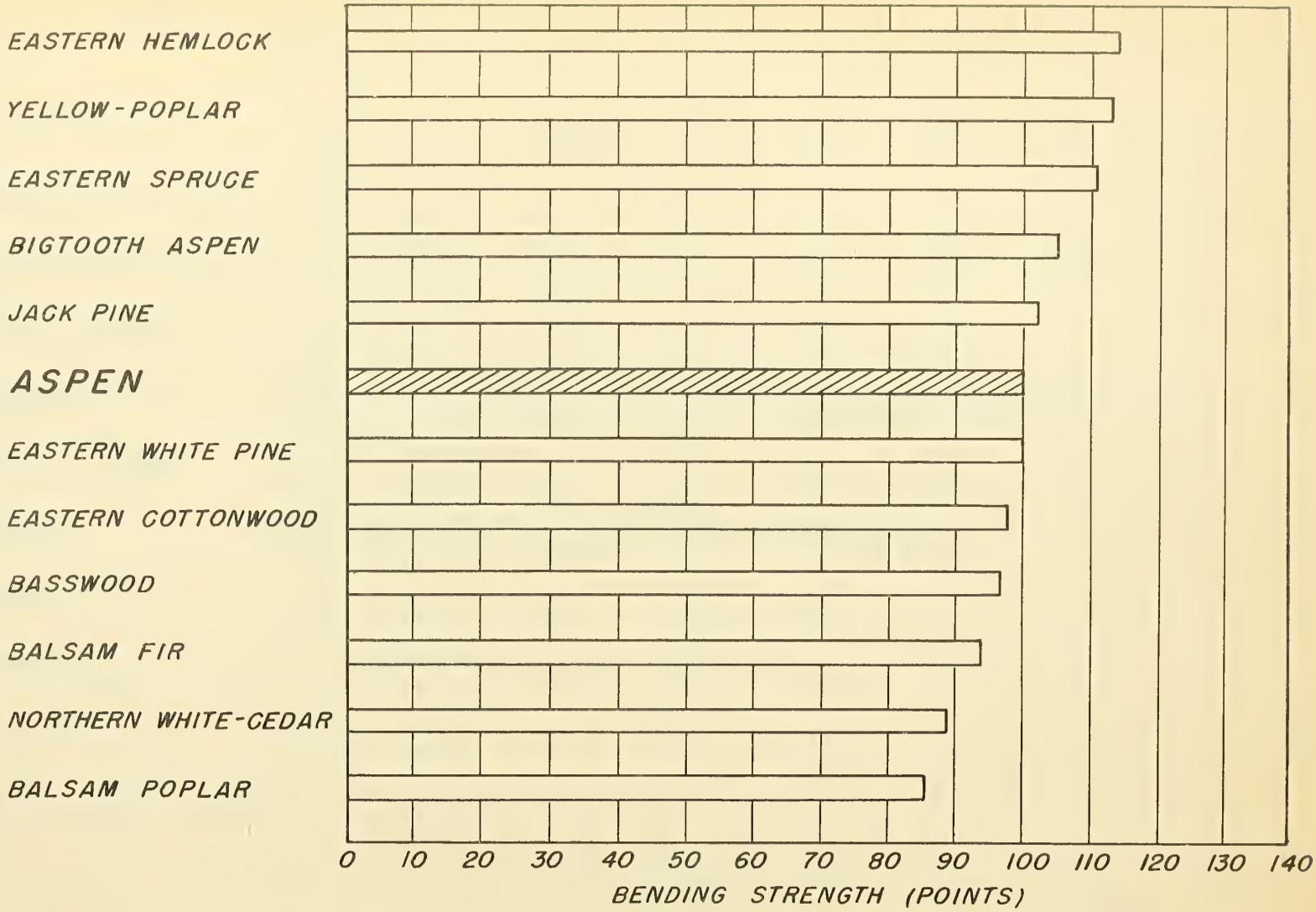

Figure 3.--Average bending strength of the clear wood of aspen compared with several other species.

The bending strength of aspen compares favorably with that of a number of important commercial species. The strength of large-sized stringers, heavy joists, and rafters depends primarily on the size, number, and location of knots and other defects.

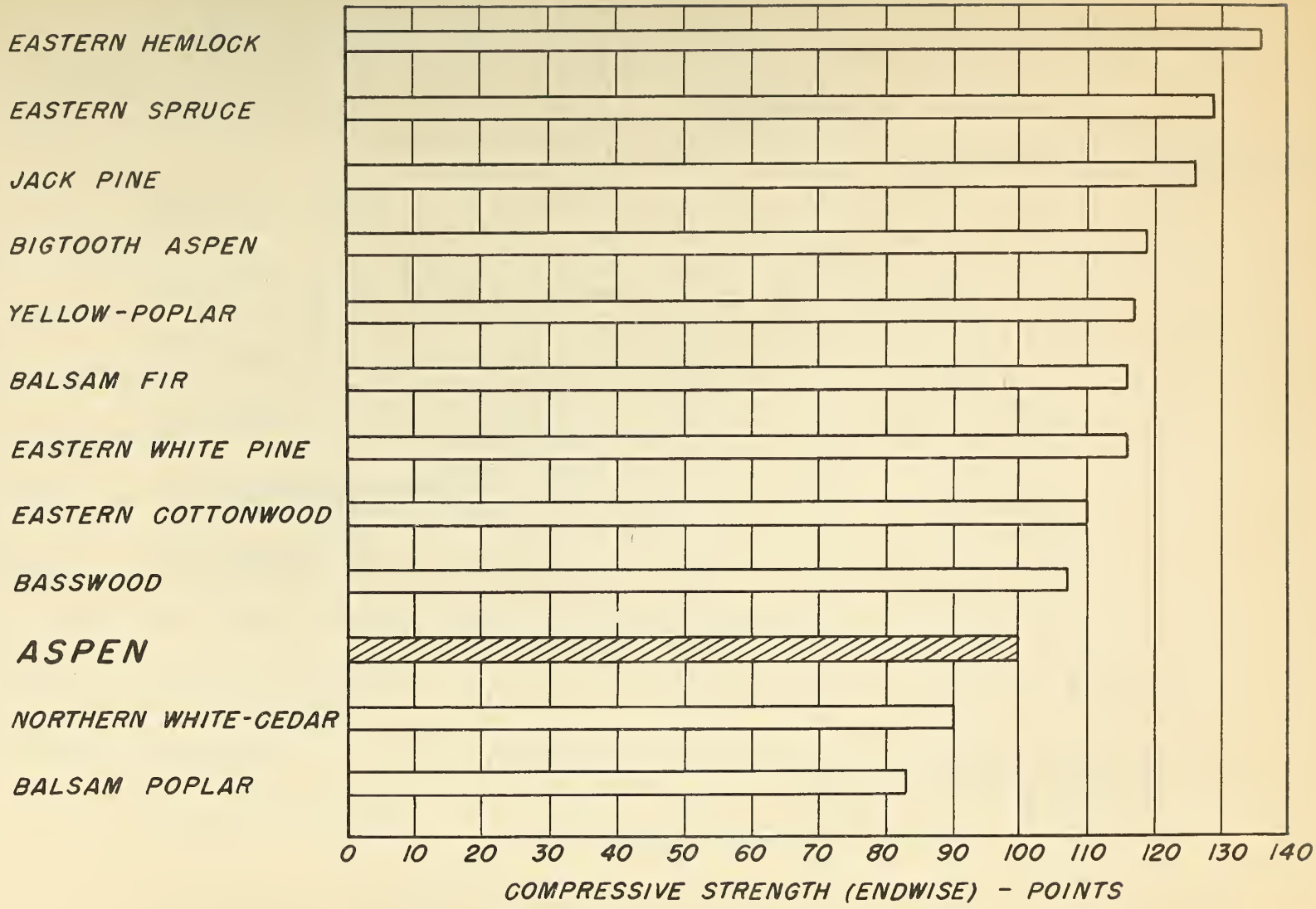

Figure 4.--Average compressive strength (endwise) of the clear wood of aspen compared with several other species.

Aspen posts and short columns have low load-carrying capacity. The strength of large-sized posts depends mostly on the size, number, and location of knots and other defects.

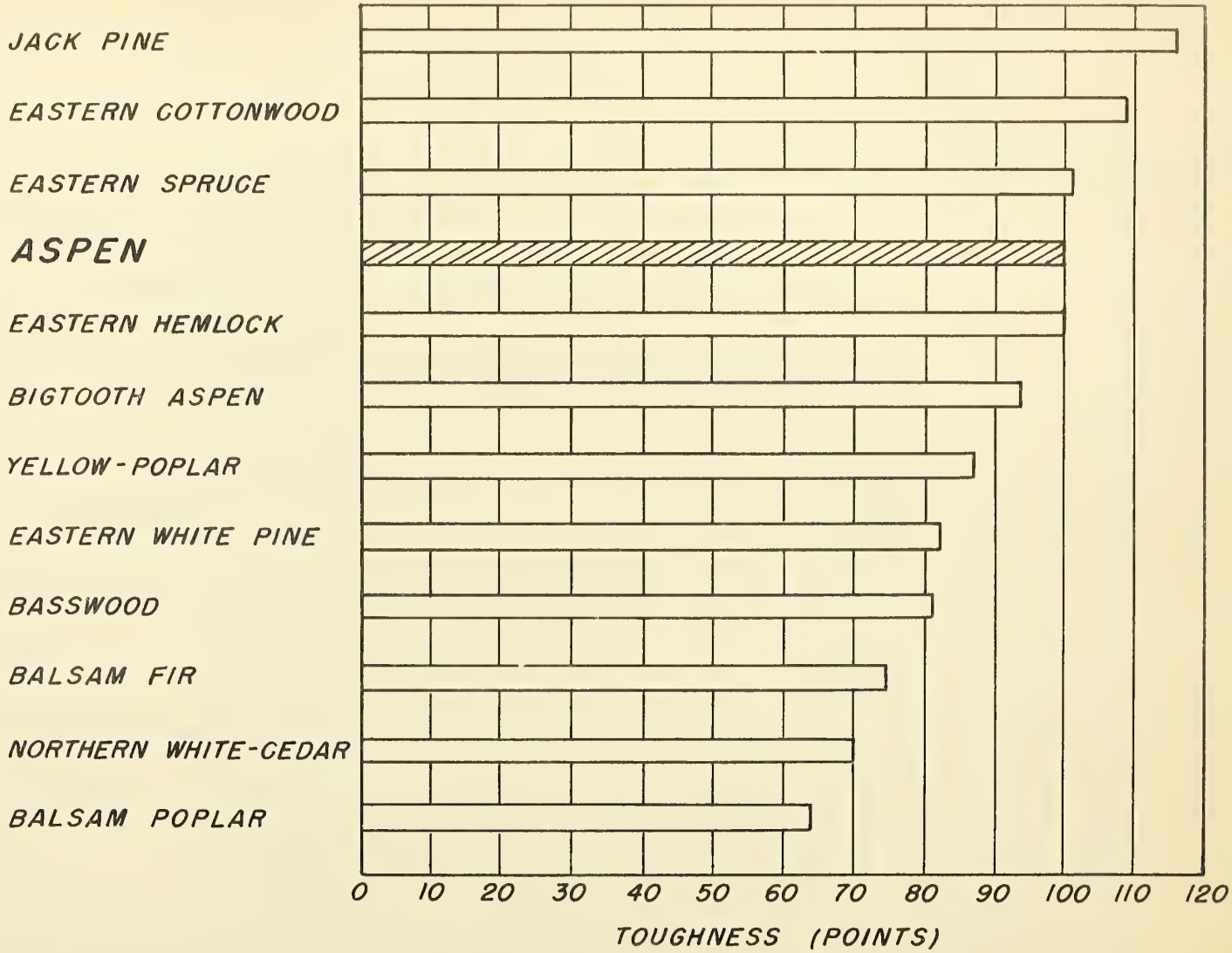

Figure 5.--A comparison of the average shock-resisting ability or toughness of the clear wood of aspen with several other species.

The shock-resisting ability of aspen contributes to its successful use as canoe frames, matches, excelsior, toys, and crating.

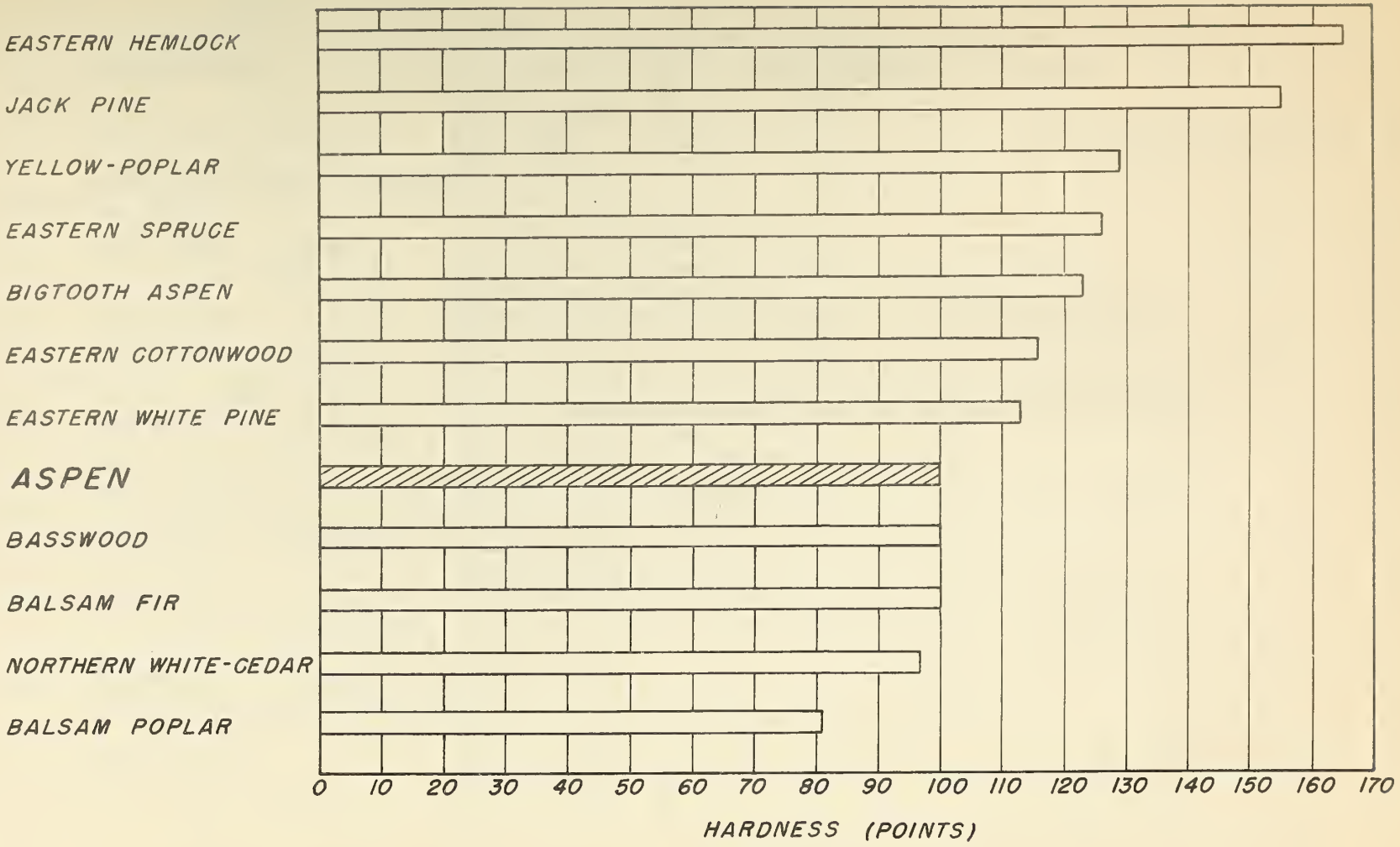

Figure 6.--Average hardness of aspen compared with several other species.
Aspen is a soft hardwood. It is suitable for uses where softness rather than hardness is desired.

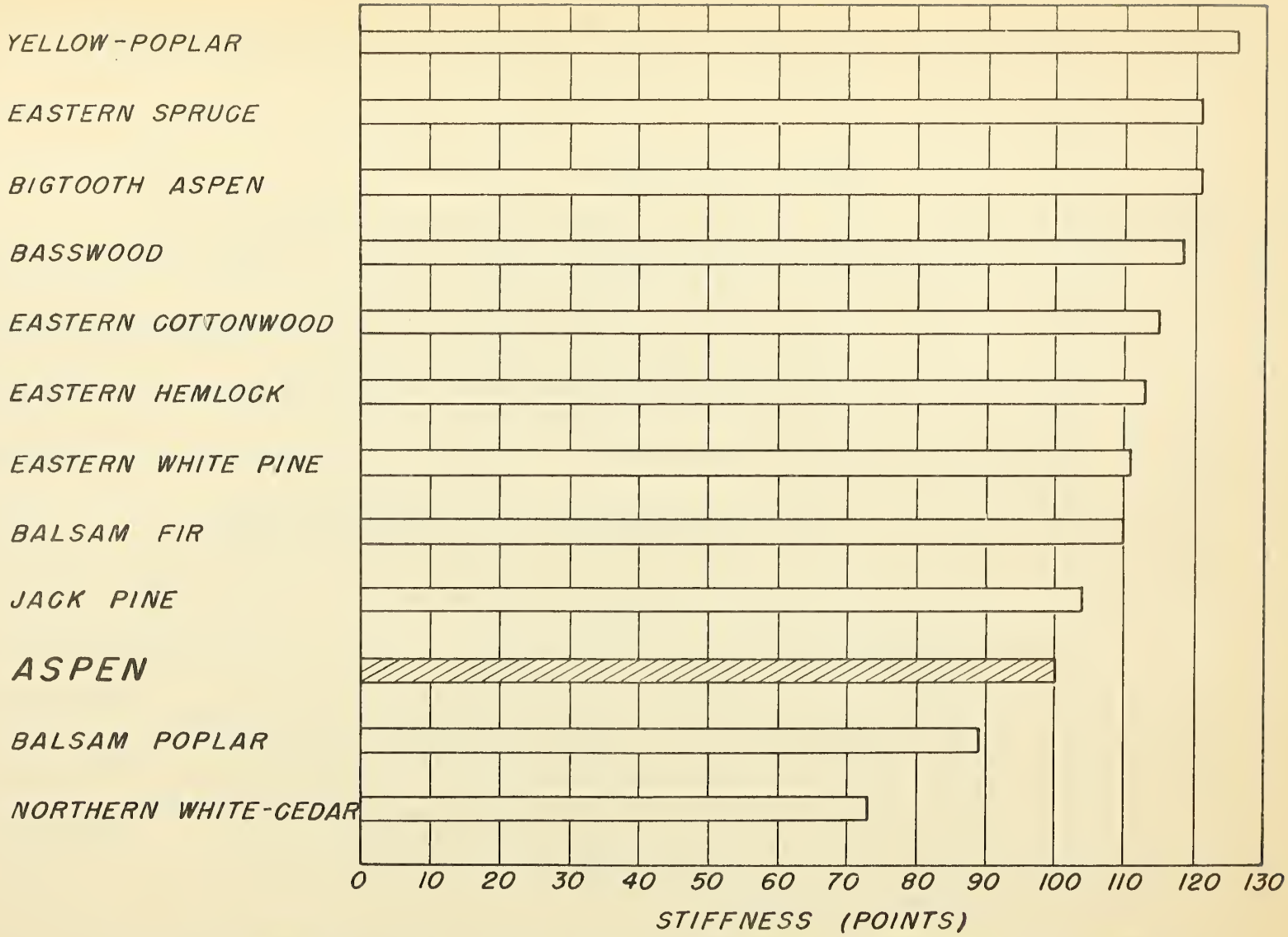

Figure 7.--A comparison of the average stiffness of the clear wood of aspen with several other species.

Aspen is not a stiff wood, but oversizes are not necessary to obtain sufficient stiffness to meet the requirements of most of the uses into which the wood goes.

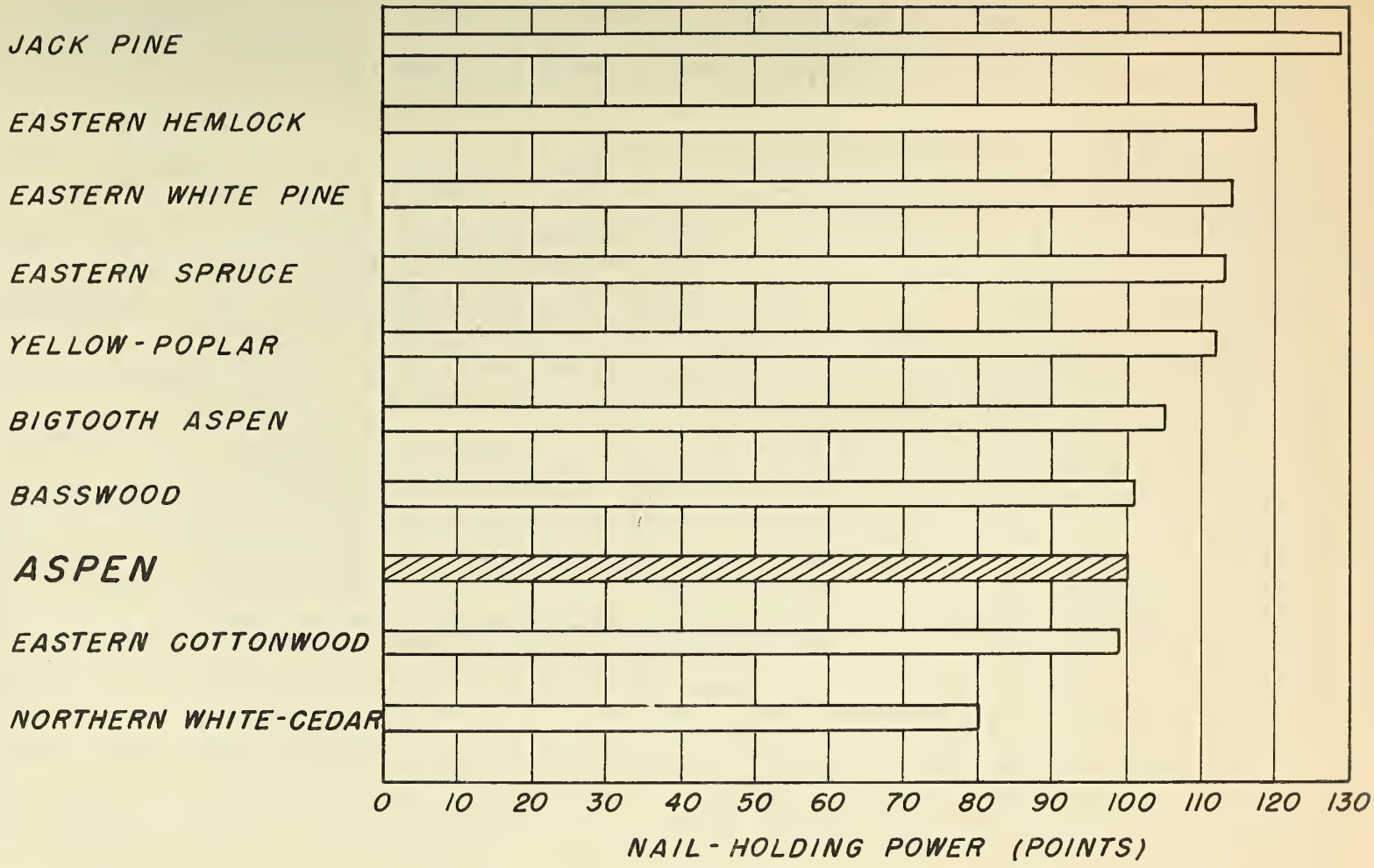

Figure 8.--The nail-holding power of aspen compared with that of several other species.
Aspen has about the same nail-holding power as some of the soft hardwoods of light weight, but it has somewhat less nail-holding power than white pine. In service, the small tendency of aspen to split in nailing results in little loss in holding power from this cause.

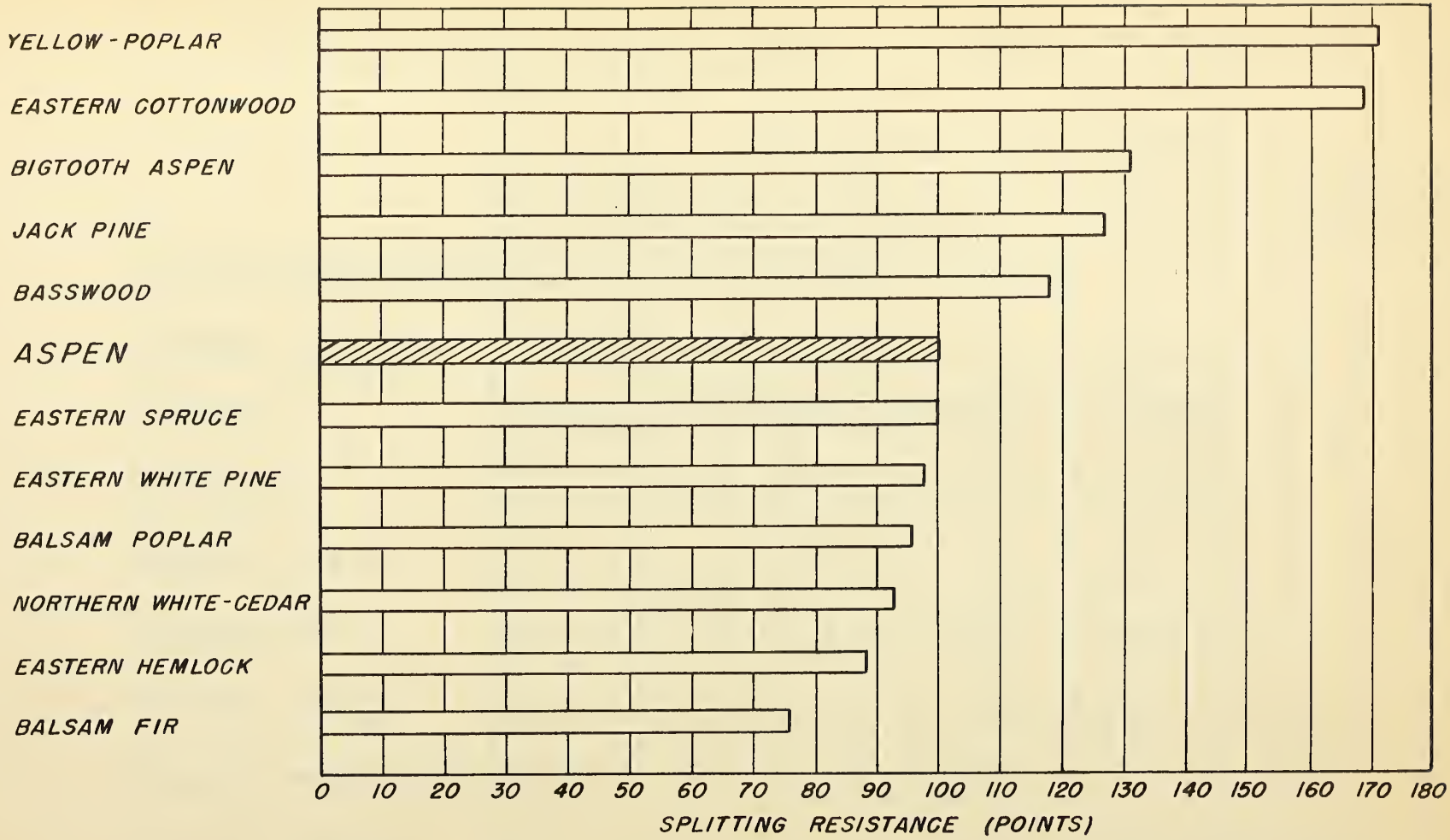

Figure 9.--Comparison of the splitting resistance of the clear wood of aspen with that of several other species.

Splitting resistance is a measure of the resistance to splitting from the action of wedges and bolts but it is not a measure of the tendency to split in nailing, which is dependent largely on the hardness and texture of the wood.